Research on Contrast Color Matching of CNC Panel Buttons Based on Eye Movement Experiment

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Abstract: Purpose The color matching of the key-intensive areas of the control panel of the CNC machine tool still lacks a considerable design, so we are looking for a color matching design scheme that can quickly distinguish the keys to improve work efficiency. Method A case study is carried out on the CNC panels of different types of CNC machine tools, the eye movement experiment is used to test the identification effect of contrasting colors in the button-intensive area, and the user's perception effect on color matching is obtained by combining the interview method. Results The red and blue contrast color matching enhances the visual appeal, reduces the time for users to find the target key, improves work efficiency, reduces the error rate, reduces the mechanical indifference of the key area, and makes the product full of vitality and warmth. Conclusions The use of contrasting colors in the key-intensive area of the CNC panel can promote the efficiency of people to distinguish and find the target keys, and so on. The application of other contrasting color schemes in the key area of the CNC panel can create a design with obvious local features of the product, and finally realize the psychological Improve the user experience in all aspects, such as emotional and emotional aspects.

Keywords: eye tracker, numerical control panel, key-intensive area, contrast color matching, improve work efficiency

1. Introduction

Color has a stimulating effect on vision, whether in visual communication or product design, it often has the power to grab people first, which is the main manifestation of the visual impact of design that people often say[1]. The special sensitivity of human vision to color determines the important value of color matching in design. The domestic focus on the design of CNC machine tools in terms of modeling, color matching, human-computer interaction, and emotion has increased sharply. It has attracted much attention both inside and outside the industry. The research on button color matching of CNC machine tool control panels will also use concepts such as contrasting color matching, human-computer interaction, etc., combined with eye movement experiments, user interviews and other methods to conduct test research.

2. Application principle of contrast color matching in CNC panel

In this experiment, contrasting colors are selected for color redesign of the key-intensive area of the numerical control panel. This principle comes from the 12-hue ring diagram summarized and drawn by the German Bauhaus educator Jonesy Ayton based on the color table of Newton's spectral research[1-2]. In the 12-color circle diagram, with the center of the color circle as the center and a certain color as the basis, any two colors separated from this color by 120°~—150° are the contrasting colors. The color matching of the contrasting colors has a strong contrast, and its effect Bright and full, it is easy to bring people a clear and clear visual experience and experience effect (as shown in Figure 2.1 below). Use appropriate contrasting colors in the key-intensive area of the CNC panel, which does not conflict with the high-saturation color of the special keys of the CNC panel, not only It can improve the user's perception effect, reduce visual fatigue to a certain extent, and improve work efficiency

Figure 1 Color wheel diagram (picture from the Internet)

2.1 Design and Application Principles in Key Areas of Contrasting Color Numerical Control Panels

In the color matching design of various product planes, generally bright colors and higher saturation colors can attract the attention of users. Therefore, red, yellow, etc. are chosen for the color design of special buttons such as emergency buttons on the CNC panel of CNC machine tools for warning colors[3-5]. However, at present, the ordinary and conventional buttons of CNC machine tools are dense, and the color is single, mostly white, gray and other colors with low brightness and little color difference (as shown in Figure 2.2 below), the recognition is not high enough, and there will inevitably be errors or visual errors during operation. Fatigue affects work efficiency and will have a negative impact on human-computer interaction[6]. For the key area of the CNC panel with a lot of information content, the designer should first consider the use efficiency and recognition of the keys, and try to make the number of colors moderate, the saturation should not be too high, and do not collide with colors such as emergency keys. Under certain circumstances, color design can improve the user's work efficiency to a certain extent.

Figure 2 Part of the CNC panel picture (the picture comes from the Internet)

2.2 Design Choices in Contrasting Color Numerical Control Panel Key Areas

When the author collected a large number of CNC panel pictures, I found that most of the emergency buttons on the panel are red or accompanied by a small part of yellow, and other special buttons are often red, green or blue, because generally in the same panel design, the number of colors is 3- 5[7-8], but due to the small size of the CNC panel itself and many buttons, too many colors will appear redundant, which will affect the correct rate and recognition effect of user operations, so when choosing the contrast color for the experiment, the author has selected The two colors of blue and yellow are the starting point to choose contrasting colors. In total, the following two sets of different hues of blue and yellow are selected. At the same time, in order not to collide with and affect the colors of other emergency keys on the CNC panel, and adjust their saturation, each pair of contrasting colors is reduced in saturation and made into 3~4 groups.

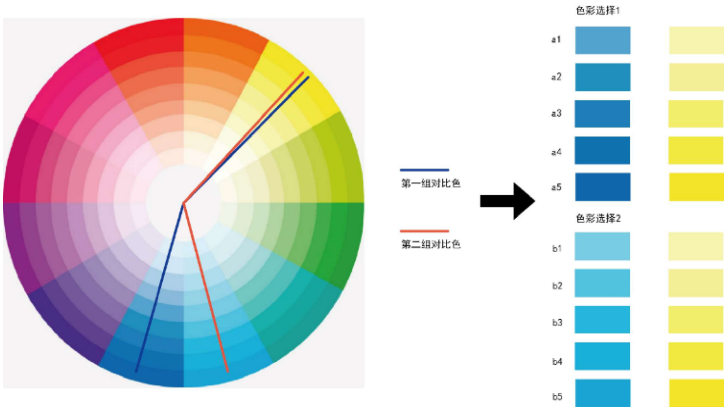


Figure 3 Color selection Image source: The author combined the network map to draw

2.3 Color vision capabilities for contrasting colors

The contrasting color scheme selected in this experiment is selected based on the overall style and tone of the CNC panel of the CNC machine tool. The design of the contrasting color in the key area of the CNC panel not only breaks the indifference style of mechanical industry products, but also highlights the human-centered design orientation and improves the User recognition and efficiency.

2.3.1 Improve visibility

The color saturation and brightness of the contrasting colors are different. In the design, the inherent color of the product or other factors are used to improve the color recognition and consolidate the memory. In this experiment, two contrasting colors, blue and yellow, are selected to match the existing red of the product. Etc. to expand the difference between each other's colors, increasing the unique visual effects of each color. The difference in product color will show a neat effect[9-10], which not only creates a strong identification, but also uses the color identification to color the keys of the CNC panel, which can also strengthen the product characteristics and enhance the effect of human-computer interaction.

2.3.2 Reduce psychological burden

Due to the nature of the product and the working environment, CNC machine tools give people the impression of being mechanical, indifferent, stiff, and rigid. In long-term use, it will bring certain physical and psychological pressure to users, and users are most likely to operate CNC machine tools. It is through the interaction of the numerical control panel[11-12], the numerical control panel has become the biggest object to improve the relationship between people and the machine tool, and there are many buttons on the numerical control panel, which are more complicated, and a single gray-white color will also bring depression in long-term use. In recent years, many scholars have begun to pay attention to the diversified color matching of CNC machine tools and CNC panels. Generally speaking, there are dominant colors, foil colors, and embellishment colors in color matching design. The collocation of these colors is flexible[9]. This experimental design can improve the color emotion through the contrasting colors of blue and yellow. The human-machine relationship adds some decorative interest and vitality, allowing users to obtain warm spiritual comfort in the indifferent mechanical working environment, reducing the operator's psychological burden to a certain extent [13-15]

3. Scheme design

3.1 Analysis of the Arrangement of CNC Panels

In the early stage of this experiment, the products of the top nine brands of CNC machine tools in China in 2021 were selected. After collecting most of the machine tool samples on the official website, according to the CNC panel of the CNC machine tool, the layout of the key area is summarized as follows: 1. Half-enclosed Type, 2 up and down type, 3 left and right type. As shown in Figure 3.1 below.

Figure 4 The picture comes from the author's summary

By subdividing the above three types of CNC panel layouts, it is concluded that there are two types of semi-enclosed and left-right layouts. There are five types of layouts in total, which can be named as semi-enclosed 1 and semi-enclosed 2. , up and down, left and right 1, left and right 2.

3.2 Numerical control panel experiment button drawing

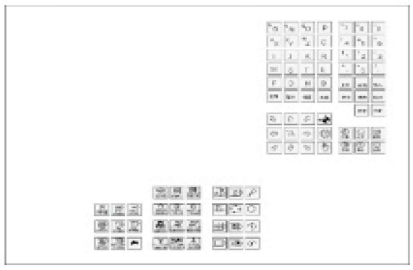
Due to the differences in the manufacturers of many CNC panels and the types of machine tools they belong to, there are also certain differences in the key functions and contents of the key-intensive areas of the panels, but in general, there are number, letter keys and icon keys. Resources, draw more general icons and use them in the experimental diagram, such as the icon combination in Figure 3.2 below.

Figure 5 Image source: the author's own drawing

3.3 The Application of Contrasting Colors in Numerical Control Panel Keys

The arrangement of the extracted five types of buttons is drawn into a diagram. The arrangement diagram consists of five groups of samples. The original gray-white samples and the contrasting color selected by the author are applied to the five groups of samples. The pictures are as follows, and each group has a name. (In order to exclude the influence of other special keys, it is omitted when drawing a map. When drawing a map, the size of the outer frame, the number and size of the internal key area, and the content are considered to be unified, etc.), as shown below:

(1) half surround 1



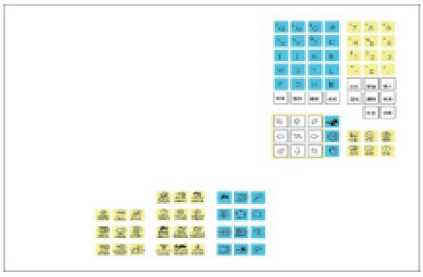


Figure 6 a: off-white group *b: blue-yellow contrasting color group*

(2) half surround 2

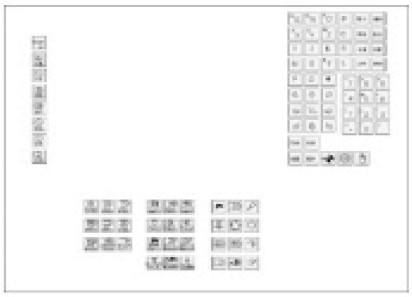


Figure 7 a: off-white group b: blue-yellow contrasting color group

(3) top and bottom

Figure 8 a: off-white group *b: blue-yellow contrasting color group*

(4) left and right 1

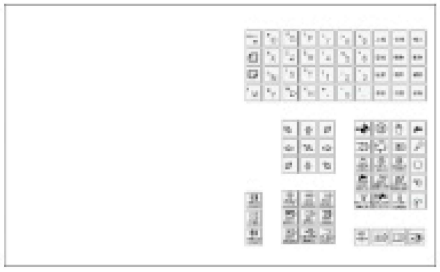
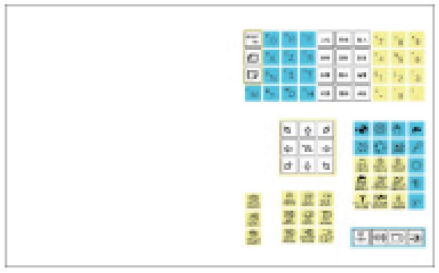


Figure 9 a: off-white group



b: blue-yellow contrasting color group

(5) left and right 2

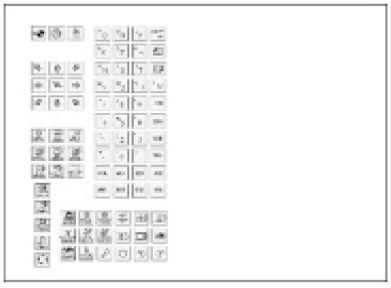
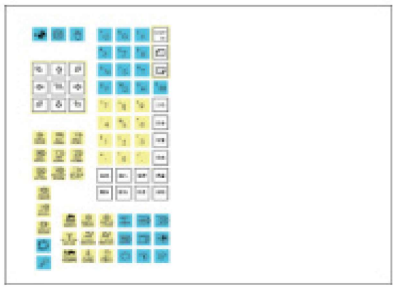


Figure 10 a: off-white group



b: blue-yellow contrasting color group

4. Eye movement experiments

4.1 Experimental instruments, experimental objects and test samples

Eye movements can accurately measure and record the different trajectory features and attention of the human eye when processing visual information [12]. In this experiment, the eye tracker of "Aiweishi" brand is used, the model is EV-DP1 desktop eye tracker, the data collection principle is eye position extraction, the sampling rate is 60 Hz, the tracking accuracy is 0.5°~1°, and the delay Time < 20 ms. The subject faces the computer screen, and the binocular acquisition method is 50-70 cm relative to the screen. Before the formal experiment, a simulation experiment is carried out, and the subject is required to perform a simulation search command in the image and record the time, and finally take the average value, so the sample test time is 10 s.

Twenty subjects were enrolled, all of whom were college students, aged between 18 and 26 years old. Among them, ten males and ten females had uncorrected visual acuity above 1.0, and no color blindness or color weakness. The test samples come from the five types of key distribution diagrams of the interactive control panel that the author has summarized and drawn. They are colored in gray and white and selected contrasting colors. They are divided into 2 groups of experimental samples, with a total of 10 specific samples, of which the participants participated in experiment one. There are 10 students in the (grey and white group), 5 boys and 5 girls, and 10 students who also participated in

the second experiment (contrast color group), 5 boys and 5 girls. A test of two variables is carried out for the color of the key area of the numerical control panel, that is, the test of the influence of the two variables on the human visual search efficiency.

4.2 experimental task

In order to understand the efficiency of the subjects in finding the target instructions on the CNC panel, before the test, the test subjects gave several self-made combinations of instructions, including three main types of keys: letters, numbers and icons, and the selection was more difficult. Moderate icon. The subjects were asked not to look around after finding the command, and to focus on the last command as much as possible. As shown in Figure 3.1 below

Figure 11 Instructions to be found (drawn by the author)

The subject sits in front of the computer screen naturally and comfortably, and calibrates the eye tracker according to the prompts of the computer monitor. When the screen is green and the eyes appear and move with the subject's movement, the subject can be multi-pointed. Prediction, no data loss before formal experimentation. The subjects searched for the instructions given by the subject in advance according to the pictures given on the screen. Each picture took 10s, and a group of experiments ended directly. Subjective questionnaires and user interviews were conducted on the test subjects.

4.3 Experimental process

In order to ensure the validity of the experiment, this experiment was carried out in the same environment, and the test subjects were first asked to remember the instructions given by the main tester. Before the start of the experiment, the experimenter will explain the experimental procedure and precautions. The specific process of the experiment is shown in Figure 2 below.

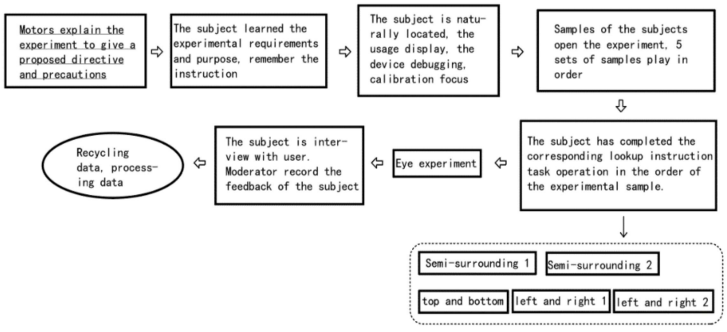


Figure 12 The author's own drawing

The experiment is divided into two groups. The color of the button area in the first experiment is to extract the gray-white color that is one of the commonly used color matching colors of the existing CNC panels. The second experiment is to extract a group of blue-yellow contrasting colors in the color circle and reduce its brightness. To use, the subjects searched for the instructions given by the subject in each group of samples.

4.4 Data and Analytics

The heat map, trajectory map and grid map of each task in 5 different samples of the subjects completing the first and second experiments are shown in Table 3.2 below.

4.4.1 Heat map

The distribution of several groups of heat maps in Experiment 1 is relatively scattered and has a large range. In addition to the error of the experimental equipment, according to the color of the circular light spot in the figure, it can be seen that the focusing degree is not accurate enough, and the subject's vision is a little confused. The focus point of the heat map of experiment 2 is relatively concentrated and the scope is relatively small.

In this experiment, the order of the two groups of experiments is half-enclosed 1, half-enclosed 2, up and down, left and right 1, left and right 2. It can be seen from the experimental heat map that the first two groups of pigs with yellow and blue contrasting colors are painted with hot spots, and the focus is not focused enough. The three groups were slightly scattered. From the interviews after the experiment of each group, it was known that the subjects needed to adapt to the content and speed of the experiment, so the eyes were scattered at first, and the visual attention was not enough, but in the later experiments, they gradually adapted and quickly Find the target directive. Compared with the yellow-blue, contrasting color group, and the gray-white group, the heat map is always scattered and not focused enough. This also shows that the use of gray-white and other colors in the key area will have a certain impact on the efficiency of the user to find the target command.

4.4.2 Initial view point trajectory diagram

It can be seen from the line of sight trajectories of the ten subjects that the initial and overall sight trajectories of the five groups of samples in Experiment 1 are scattered, with many locus points. The distribution area is wide and the time distribution is not uniform. The initial view point of the second sample is on the button, the line of sight trace is relatively regular, and the point of the line of sight trace on the target command is relatively forward. The overall point of sight trace is less and more regular, and the coverage is not as large as that of the experimental group.

4.4.3 Grid map/dwell time

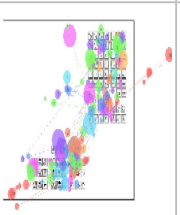
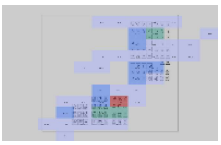
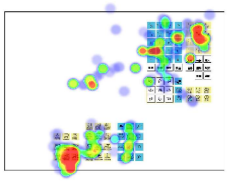
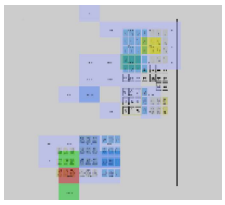
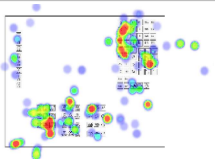
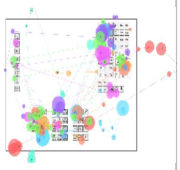
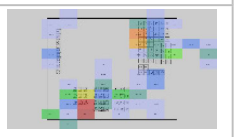
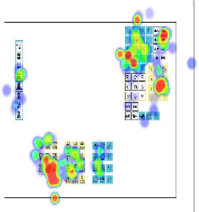
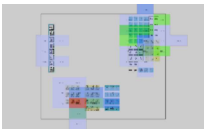
The grid diagrams of the two groups of experiments were extracted and made into a data table. B is the abbreviation of the subjects. The effective dwell time and average time in the grid diagrams

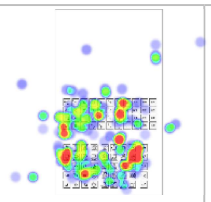
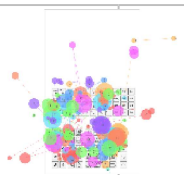
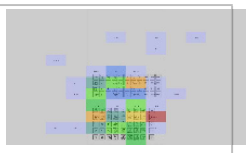
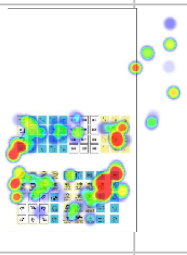
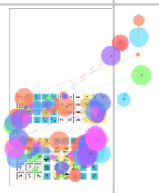
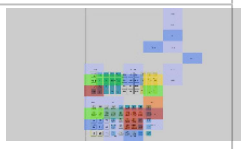
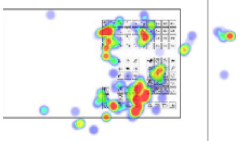
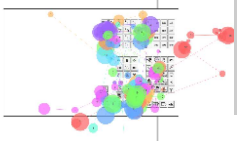
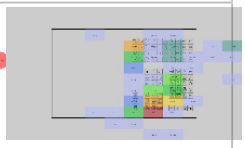
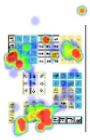
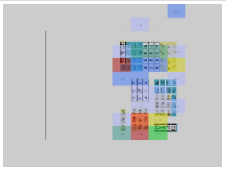
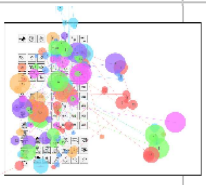
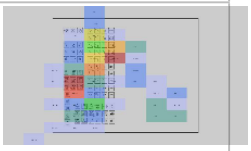
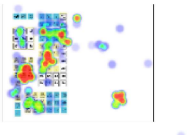
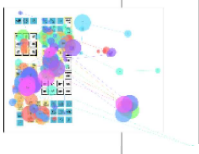
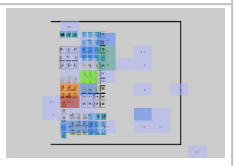
of the ten groups of samples are as shown in Table 3.1. Due to the slightly scattered sight of the experimental sample, the subjects The time for the user to look up and stay on the command button is not average enough. The duration is from 200 to 1000. Although the grid time of experiment 2 is also different, it is generally longer than that of experiment 1, and it can be seen from the grid diagram. , Experiment 1 has more visual stops, and Experiment 2 has less and relatively long data. It can be seen that the recognition rate of the blue-yellow contrast color group of Experiment 2 is higher than that of the gray-white group of Experiment 1, and there is a grid time It can be seen that in the second experiment, the dwell time for the sample to find the corresponding instruction is shorter, the last fixation point is longer, and the complete instruction button has been found.

Table 1 Summary of experimental data

		B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	average
Semi-surrounded 1	Gray white group	632	337	350	957	805	221	327	474	400	438	494
	Blue-yellow contrast color group	1516	1665	1342	1109	1238	1632	1209	1548	1438	1687	1593
Semi-surrounded 2	Gray white group	977	604	673	759	710	614	456	213	371	439	575
	Blue-yellow contrast color group	1891	1775	1644	1664	1484	1710	1594	1531	1409	1633	1634
top and bottom	Gray white group	577	559	683	317	589	571	250	545	678	271	504
	Blue-yellow contrast color group	1280	1132	1588	1371	1594	1980	1484	1582	1397	1669	1508
left and right 1	Gray white group	515	429	396	579	799	438	421	308	730	730	535
	Blue-yellow contrast color group	1882	1856	1735	1815	1766	1598	2124	1503	1788	1764	1783
left and right 2	Gray white group	382	438	461	654	435	172	671	422	554	595	478
	Blue-yellow contrast color group	1776	1754	1877	1383	1087	1520	1638	1970	1893	2640	1754

Table 4.2: Experimental Results

sample		Hotspot	Trajectory	Grid map
Semi-surrounded 1	Experiment 1: Gray white group			
	Experiment 2: Blue-yellow contrast color group			
Semi-surrounded 2	Experiment 1: Gray white group			
	Experiment 2: Blue-yellow contrast color group			

top and bottom	Experiment 1：Gray white group			
	Experiment 2：Blue-yellow contrast color group			
left and right 1	Experiment 1：Gray white group			
	Experiment 2：Blue-yellow contrast color group			
left and right 2	Experiment 1：Gray white group			
	Experiment 2：Blue-yellow contrast color group			

4.4.4 User Interview Results

After the eye-tracking experiment is over, through user interviews with the test subjects, the problems encountered by the test subjects in the experiment are as follows:

(1) The interface is too small and it is inconvenient to find;

(2) The color division of the gray-white group is not clear enough, and the blue-yellow contrasting color group is more convenient to find the target instruction;

5. Conclusion

In this paper, the blue-yellow contrast color scheme design and user interviews are used to test the eye movement experiment in the key-intensive area of the CNC panel of the CNC machine tool, and the evaluation method is combined with the user experience evaluation method. Based on the conclusions drawn from the eye tracker experiment and the modification suggestions from the user interviews, the key-intensive area of the CNC panel is divided into regions, and a new color scheme is matched to design a set of work efficiency, increase recognition and fun. The color scheme of the CNC panel keys. Because this method makes up for the uncertainty of a single experimental method and the differences between different individuals, through this experiment, more color matching methods can also be applied to the future design of CNC panels, which can provide information for the design of CNC panels. The new ideas can also be extended to other human-machine interface designs.

5.1 Deficiencies and reflections of experimental research

For the button interface with a lot of content information, the designer first considers the reading function, and the color should not be distracting and hinder the user's use. In this experiment, no further experiments were carried out to verify the negative effect of blue-yellow contrast color in the entire CNC panel. . During the experiment, the instructions given by the subjects were of moderate difficulty, and no simple or complex passwords were formulated for the subjects to experiment in turn. In the subsequent experiments, the human-computer interaction process can also be simulated, and the interactive interface can be set up to allow the subjects to continue the eye-hand combined operation.

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